Florida's Micro Air Vehicle Laboratory (Lee 2004). The resulting family of systems includes a UAV constructed of composite materials such as carbon fiber, fiberglass, and aramid fiber, providing the ability to land the UAV in rough areas without damage to the craft or its payload. The craft can be easily disassembled and placed in boxes for transportation in vehicles or even aboard commercial airliners. The UAV is powered by an electric motor and rechargeable batteries, making it more reliable, safer, and quieter than UAVs powered by gasoline or nitromethane. A GPS-guided autopilot enables autonomous navigation and the ability to fly over a designated area repeatedly and with great accuracy. Recording and transmission of position and attitude data of the UAV enables photogrammetric adjustments to be made to collected imagery, allowing for the orthorectification and spatial analysis of collected photos (Wilkinson 2007). Imagery can be further analyzed using computer programs to automatically detect and quantify objects such as birds (Abd-Elrahman et al. 2005). Payloads have included visible-spectrum video, still cameras, and a thermal-infrared sensor, for research applications ranging from manatee surveys to monitoring of levees for leaks (Figure 1).

A small but growing number of companies manufacture small to medium UASs suitable for non-military applications. These aircraft have been used to collect valuable data on the absorption of sunlight by atmospheric aerosols, for example (Ramana et al. 2006). UASs are expected to become valuable tools for research in the Arctic, where they mitigate many of the safety concerns for manned flight in remote areas or over polar waters. Larger UASs, such as civilian versions of the RQ-4 Global Hawk and RQ/MQ-1 Predator, are now used for large-scale surveillance of western forest fires and hurricanes by the U.S. Forest Service and National Oceanographic and Atmospheric Administration.

Industry and academia have only begun to explore UASs as platforms from which to monitor environmental attributes and ecological phenomena. As new applications continue to arise, UASs are likely to revolutionize the methods employed in our discipline in the same ways that GIS has changed the natural sciences. With respect to this technology and the promise it offers for improvements to safety, efficiency, and scientific advancement, perhaps we will even be forgiven for saying that the sky is the limit.

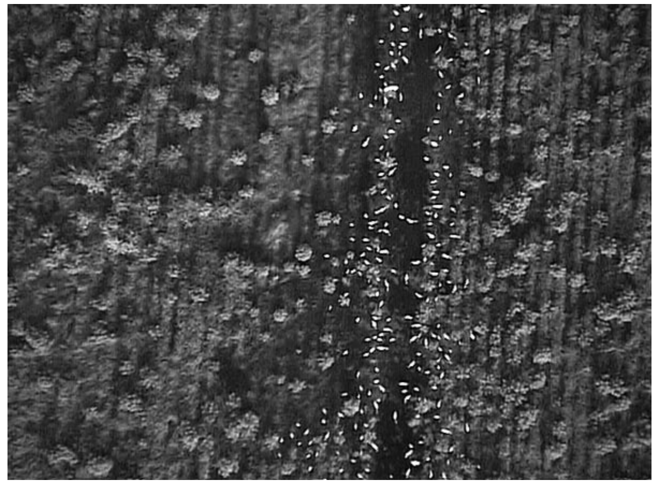

Figure 1. This low-resolution image from a UAV-mounted CCD camera shows white wading birds congregating around a drainage canal in a wildlife management area. This image was used in conjunction with image-recognition software to automatically estimate the number of birds in the image, foreshadowing a new tool to rapidly survey wildlife populations. Photo courtesy of University of Florida

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Estimating Population Size of Mexican Wolves Noninvasively (Arizona)

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Monitoring wolf abundance is a significant problem confronting biologists coordinating the recovery of the Mexican wolf (*Canis lupus baileyi*) population in the Blue

Figure 1. A female Mexican wolf (*Canis lupus baileyi*) from the population in the Blue Range Wolf Recovery Area in Arizona and New Mexico. Researchers use radiotelemetry to monitor noninvasively. Photo courtesy of USFWS

Range Wolf Recovery Area (BRWRA) in Arizona and New Mexico (Figure 1). Thus far, radiotelemetry has been a satisfactory method. However, collaring and tracking more wolves in the expanding population is expensive. The development of a cost-effective method to estimate Mexican wolf populations will assist the long-term management and recovery of wolves.

We are attempting species and individual identification using DNA extracted from wolf scat because scat is both readily available and easy to collect (Putman 1984). Progress in contemporary molecular genetics has made noninvasive genetic sampling of an animal population possible (Goossens et al. 2000, Prugh et al. 2005). The ability to identify an individual through DNA amplification of a scat sample allows us to treat reoccurrences of a genotype in additional samples as marked recaptures. Mark-recapture models may then be used to estimate population size based on collected genotypes. We are currently developing appropriate laboratory, sampling, and field protocols to collect scat and conduct a genetic mark-recapture study of Mexican wolves in a portion of the BRWRA.

We tested our ability to identify individual Mexican wolves in the lab by collecting scat and blood from eight captive wolves at the Sevilleta National Wildlife Refuge in New Mexico. We stored scat samples in 50-ml centrifuge tubes along with silica beads to act as a desiccant (1:4 scat to silica beads by volume), using filter paper barriers to prevent silica dust from embedding itself on the surface of the scat. We extracted DNA from surface scrapings of scat following the protocol for human DNA analysis from stool samples (QIAGEN 2007). We have successfully amplified 10 canid specific microsatellite markers (Ostrander et al. 1993) in the Sevilleta samples. These markers allowed us to obtain individual genotypes for all eight wolves. We are in the process of cross-checking genotypes obtained from scat against those obtained from blood.

We have demarcated a compact study area within the BRWRA comprising approximately 2,500 km² in the Apache Sitgreaves National Forest in Arizona. The Interagency Field Team, which coordinates the recovery project, is using radiotelemetry to monitor wolves in the study area and knows precisely how many wolves exist there. The study area is occupied by four packs (Paradise, Hawk's Nest, Bluestem, and Rim) whose territories are contiguous with each other. Furthermore, there are no unoccupied regions within the study area that could be colonized during the duration of the study. Therefore, this study area presents us with an opportunity to use radiotelemetry estimates as a baseline to evaluate the precision and accuracy of our technique.

Wolves are known to travel along existing roads, trails, and waterways and often deposit scat along these pathways (Mech 1970). Consequently, we have laid out eight approximately 60-km transects, some of which intersect two or three pack territories, along Forest Service roads in the study area. The total length of all transects is approximately 500 km. All transects are navigable by four-wheel drive, high-clearance vehicles. After first clearing all transects of scat, teams of two volunteers in vehicles driven at speeds not exceeding 20 km/h surveyed these transects on two consecutive weekends in September 2007 and collected all observed canid scats—a total of 52 samples. These transects will be surveyed again in a similar manner for three consecutive weekends in November 2007, February 2008, and April 2008.

We will use mark-recapture modeling to analyze the encounter histories generated by genotyping collected scat. However, two of the four packs are known to occupy territory outside the study area. Thus some wolves are likely to have a much higher capture probability than others, leading to low-biased population estimates under the usual model assumption that all animals have an equal probability of capture. We will attempt to overcome this difficulty by logging the distance between scat location and the edge of the study area. We will use this individual covariate to explain the variation in capture rates between individuals. The primary collection events will be modeled using a Huggins-type population estimation model (Huggins 1989), which allows for individual covariates such as average distance to the edge of the study area. The data will be analyzed using the robust design in Program MARK (White and Burnham 1999) that allows for the trading of information between primary capture periods and simultaneously allows us to estimate survival rates. We will evaluate the effectiveness of our method by determining if the confidence interval for estimated population size contains the actual population size in each sampling period.

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Control of Maidenhair Vine (*Muehlenbeckia complexa*) (California)

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A native of New Zealand that grows both as a shrub and by winding around other plants, maidenhair vine (*Muehlenbeckia complexa*) has become naturalized along parts of California's northern coast, including San Francisco Bay (NatureServe 2007). In the city of San Francisco, maidenhair vine has invaded and become dominant in several natural areas in the Presidio, part of the larger Golden Gate National Recreation Area. Local staff observed maidenhair vine in several locations in the early 1990s. In 1994 and 1995, in an attempt to control the invasive plant, the San Francisco Conservation Corps brush-cut one area of the Presidio. Without further treatments or monitoring, maidenhair vine reestablished itself throughout the site and by 2004 again dominated the area.

To evaluate maidenhair vine control treatments and inform future removal and restoration projects, I conducted an experiment at the previously brush-cut site. The site, approximately 30.5 m × 30.5 m, is at the headwaters of a small creek in the northwest section of the Presidio. Maidenhair vine covered an estimated 78 percent of the site, forming large hummocks over the landscape, covering other vegetation, and growing up the trunks of trees (Figure 1). Hummocks grew to approximately 1.5 m in height, likely on top of other vegetation. Other vegetation visible on the site was limited to ivy (*Hedera* spp.) and Himalayan blackberry (*Rubus discolor*). Large eucalyptus and other landscape trees surrounded the site.

Figure 1. Project site in July 2004, prior to vegetation removal (left of path). Maidenhair vine (*Muehlenbeckia complexa*) dominates, forming hummocks over other vegetation and climbing tree trunks. Photos by Tania Pollak

Figure 2. Project site in December 2004 after vegetation removal and experimental treatments. Foliar spray plot is visible below and slightly to the right of the large trees. Two plots covered with woodchips on top of fabric are also visible in lower portion of photo. Macerate, clip, and control plots are adjacent to the fabric plots.

I compared six treatments: 1) cutting stems to a few centimeters above ground (clip); 2) cutting to short stems and mashing stem tips with brush cutters (macerate); 3) removing all vegetation to bare soil (scrape); 4) covering vegetation with landscape fabric (fabric); 5) applying glyphosate in the form of 2% Rodeo (foliar spray); and 6) initial vegetation clearing only (control). Because little is known about effective removal of maidenhair vine, most methods were designed to treat individual stems of the plant.

In September 2004 contractors prepared the experimental site by removing the majority of vegetation. Chainsaws were the most effective method for vegetation clearing,